Transitioning to a Circular Economy through Network Governance

The Case of the Nigerian Oil and Gas Sector

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Abstract

Environmental challenges such as climate change, pollution, and resource depletion associated with fossil fuel based industrial activities have intensified calls for a transition away from linear "take–make–dispose" economic models towards more circular regenerative approaches. The circular economy (CE) is an economic model that seeks to minimise waste, reuse materials and optimise resource use, offering a pathway to more sustainable business practices. However, transitioning to CE cannot be achieved by a single firm alone; it relies on collaboration, coordination and long-term interactions between organisations that exchange resources, knowledge and technologies. Therefore, industrial networks are crucial to transition towards CE practices. Despite this importance, the role of industrial networks in enabling CE transitions remains under-researched, particularly in the context of resource dependent and low- or middle-income countries (LMICs). This conceptual paper explores the role of industrial networks in enabling the implementation of CE practices in the Nigerian oil and gas sector. Recent circular initiatives in the sector such as gas flare recovery, drilling materials reuse, and repurposing of decommissioned infrastructure provide an opportunity to examine how network relationships shape CE transitions. The research draws on two complementary theoretical perspectives, the Industrial Network Approach for a relational lens to understand how long-term relationships, trust, and resource interdependencies shape collaborative action within industrial networks and on the Multi-Level Perspective to explore how niche innovations, established regimes and wider landscape pressures shape transitions. Accordingly, the study frames CE transitions as relational and networked processes rather than purely technological or policy-driven changes. The paper contributes by proposing a conceptual framework for investigating transitions to circular economy practices in the Nigerian oil and gas sector.

Keywords: Circular economy; Industrial networks; Oil and gas industry; Nigeria; Industrial Network Approach (INA); Multi-Level Perspective (MLP)

1. INTRODUCTION

Growing environmental concerns associated with industrial production have intensified global interest in transitioning towards more sustainable economic systems. Increasing levels of waste generation, resource depletion, and environmental degradation, compounded by the lack of security of energy and resources caused by global instability (McIlroy, 2026), have highlighted the limitations of conventional linear economic models based on "take–make–dispose" production and consumption patterns (Korhonen *et al.*, 2018). In response, circular economy (CE) has emerged as an alternative by prioritizing waste reduction, resource retention and the regeneration of natural systems (MacArthur, 2013; Kirchherr *et al.*, 2017). Despite growing emphasis on the CE in the shift to resource-efficient industrial systems, limited attention has been paid to how CE practices are enacted through industrial networks in resource-dependent economies.

Implementing CE practices within complex industrial sectors cannot be achieved by individual firms acting independently. The transition to CE necessitates more than technological innovation or policy reforms; rather it represents a multidimensional socio-technical process that involves numerous actors and institutions (Geels, 2002a). This highlights the critical importance of networks. Networks are structured interdependent relationships between firms, suppliers, regulators and other actors that foster co-innovation, enable knowledge sharing, and orchestrate complex transitions in socio-technical regimes (Håkansson and Snehota, 1995b). From the perspective of the Industrial Network Approach (INA), firms operate within business networks composed of actors, resources, and activities that are interdependent and continuously evolving through interaction (Håkansson and Snehota, 1995a). As a result, organisational change and innovation often emerge through collaboration and coordination among multiple actors rather than through the actions of isolated firms (Möller and Halinen, 2017). This network perspective suggests that the implementation of CE practices may depend significantly on how firms interact within industrial networks.

Nigeria provides a particularly relevant context for examining these dynamics, illustrating how resource dependence influences the implementation of CE practices. As one of Africa's largest oil producers, the country remains heavily dependent on the oil and gas sector for national revenue and economic development. The sector has contributed to severe environmental degradation through oil spills, gas flaring, and ecosystem destruction (Ogolo *et al.*, 2022). Responding to these challenges requires coordinated action among a diverse set of actors, including regulators, oil operators, service companies, and local communities, revealing dynamics often overlooked in IMP research, particularly power asymmetries, informal networks, and resource dependence. Emerging initiatives such as waste valorisation, gas flare recovery, repurposing decommissioned infrastructure, and the reuse of drilling materials illustrate how circular economy practices may depend on interactions across industrial networks (Adebayo *et al.*, 2024; Gaurina-Međimurec *et al.*, 2024; PWC, 2021).

This conceptual paper provides a preliminary examination of the role of industrial networks in enabling the implementation of CE practices within the Nigerian oil and gas sector and outlines a proposed research pathway to enable detailed investigation. To examine these dynamics, this study draws on two complementary theoretical perspectives. The INA offers a relational view of how firms interact through long-term relationships, resource exchange, and coordinated activities within industrial networks (Håkansson and Snehota, 1995b; Möller and Halinen, 2017). In parallel, the Multi-Level Perspective (MLP) on socio-technical transitions explains how broader structural changes occur through interactions between niche innovations, established regimes, and wider landscape pressures (Geels, 2002a).

Our contribution is a novel conceptual framework that can support research in transitions to CE models. The paper is structured as follows: it explains the main concepts of the circular economy in general and in the Oil and Gas Sector in Nigeria and the complexities of researching it; then it outlines a proposed framework to examine it, discusses issues of application and finally conclude.

2. THE CIRCULAR ECONOMY

The concept of CE has increasingly gained attention as an alternative economic model, offering systemic methods to eliminate waste and pollution, maintain product and material utilisation, and restore natural systems, thus fostering long-term sustainability (EllenMacArthurFoundation, 2021; MacArthur, 2013). CE represents a shift to more sustainable production and consumption systems, by promoting resource efficiency, renewable energy use, and waste reduction (Adebayo *et al.*, 2024).

The CE is commonly structured around three core principles: eliminating waste and pollution; circulating products and materials (at their highest value) and regenerating nature (MacArthur, 2013). These principles are operationalised through strategies such as reuse, repair, remanufacturing, and recycling, often conceptualised within hierarchical R-frameworks that prioritize waste prevention over recovery (Potting *et al.*, 2017; Geissdoerfer *et al.*, 2017). From an industrial network perspective, these CE principles are enacted through interdependent actor relationships rather than at the firm level alone, where resource circulation, value retention, and waste reduction depend on the coordination of multiple actors.

However, implementing CE within the oil and gas sector presents significant challenges, particularly in contexts such as Nigeria where weak regulatory enforcement, infrastructural limitation and policy inconsistencies constrain the adoption of circular practices (Oluwatayo and Ojo, 2024).

2.1. Circular Economy and the Oil and Gas industry

The oil and gas industry continues to be one of the key sectors in the global economy, providing over half of the world's primary energy and establishing a foundation for industries including petrochemicals, agriculture, manufacturing, and transportation (IEA, 2023). In addition to supplying energy, the sector contributes significantly to government revenues, employment, and infrastructure development, especially in resource-dependent economies such as Nigeria (Ononokpono, 2025).

However, the sector is also associated with substantial environmental impacts, including greenhouse gas emissions, oil spills, and pollution, which have intensified pressure to adopt more sustainable practices (IEA, 2021; Orisakwe, 2021).

Integrating CE principles into the oil and gas sector presents an innovative pathway for enhancing sustainability, operational efficiency, and reducing environmental impact. CE practices within the sector include recycling drilling fluids, reusing wasted water, recovering flare gas and repurposing decommissioned infrastructure (Gaurina-Međimurec *et al.*, 2024; Veriforce, 2024; Ekunke *et al.*, 2024). Specific case studies include flare gas recovery by the Norwegian energy company Equinor (Equinor, 2003), Recycling drilling fluid in Brazil (Adebayo *et al.*, 2024) and Carbon Capture by Abu Dhabi National Oil Company (ADNOC), United Arab Emirates (PWC, 2021).

Overall, these examples highlight that implementing CE principles throughout the oil and gas value chain can substantially lessen environmental impacts while improving operational efficiency. However, despite promising technologies and techniques, the rate of diffusion

remains inconsistent and frequently confined to isolated projects. In countries like Nigeria, where oil and gas operations predominate the economy, the problem resides not only in deploying technical solutions but also understanding the industrial networks and institutional dynamics that influence their implementation.

2.2. Environmental, Social, and Governance (ESG) Challenges in Nigeria's Oil and Gas Sector

Nigeria's oil and gas sector, while crucial to the country's economic development, faces major ESG issues that hinder the transition to CE practices. Environmentally, the sector has been linked to severe pollution, characterised by recurrent oil spills, gas flaring, and contamination of soil and water, especially in the Niger Delta region (Orisakwe, 2021; Lindén and Pålsson, 2013). Socially, communities in oil-producing regions experience marginalisation, inadequate compensation, and disputes over resource control, which foster mistrust and resistance to industrial activities (Edun *et al.*, 2021; Nkem *et al.*, 2022). Governance related issues such as regulatory issues, lack of policy enforcement and corruption also hinders effort to promote sustainability (Njoku *et al.*, 2025). These linked challenges not only impede the effective application of CE principles but also emphasise the need for integrated initiatives that address environmental remediation, community participation, and institutional development alongside technical advancement.

2.3. Regime Players in Nigeria's Oil and Gas Sector

The Nigerian oil and gas sector functions as a complex socio-technical system shaped by multinational firms, government agencies, financial institutions, and local actors (Emeka-Okoli *et al.*, 2024). These stakeholders influence policy and technological change through lobbying, which may be benevolent, promoting sustainability investments, or malevolent, aimed at protecting vested interests and delaying transitions (Geels, 2014; Kuzemko *et al.*, 2016). Understanding these dynamics is essential, as regime actors collectively shape the governance and direction of Nigeria's oil and gas sector (Clark and Phil, 2016; Agbakoba and Okeke, 2024). The key regime players are shown in Table 1 below:

Table 1: Regime Players in Nigeria's Oil and Gas Sector (Authors' own work)

Players in the Regime	Names of Players	Role in the System	Influence on CE Innovation
Government and Regulatory Agencies	1. Nigerian Midstream & Downstream Petroleum Regulatory Authority (NMDPRA) 2. Nigerian Upstream Petroleum Regulatory Commission (NUPRC)	Policymaking and regulation enforcement	1. Bureaucratic delays and institutional inertia 2. Overlapping mandates and regulatory fragmentation 3. Ineffective implementation of environmental laws and standards (Audu and Umana, 2024; Rezk *et al.*, 2024)
International Oil and Gas Firms	1. Shell 2. Chevron 3. TotalEnergies	Major producers and operators of oil & gas in Nigeria	1. Focus on profit and shareholder returns limits investment in CE 2. Complex joint venture agreements can slow CE initiatives 3. Reluctance to shift from established, profitable linear models (Adebayo *et al.*, 2024)
State-owned Enterprises	1. Nigerian National Petroleum Company Limited NNPC LTD	Resource ownership, partnerships with IOCs	1. Bureaucratic inefficiency, political intervention, and competing economic priorities frequently impede innovation and sustainability transitions
Investors and Financial Institutions	1. Nigeria Sovereign Investment Authority (NSIA) 2. International investors such as African Finance Cooperation (AFC), Norwegian Sovereign Wealth Fund, Qatar Investment Authority etc.	These investors are central to the development, operation, and long-term direction of Nigeria's oil and gas sector, with many placing emphases on: 1. Upstream and downstream operations 2. Infrastructure development 3. Energy transition	1. Risk aversion to unproven CE business models 2. Regulatory and policy uncertainty 3. Currency and macroeconomic risks: Volatility in exchange rates and inflation can deter long-term investment 4. Risk aversion to new business models (CPI, 2022; Rezk *et al.*, 2024)

Indigenous Oil and Gas Firms	1. Oando 2. Seplat Energy 3. Green Energy Limited	Crude oil production	1. Limited capital and technology access for CE adoption 2. Shortage of skilled personnel 3. Faulty security architecture (Olujobi *et al.*, 2024; Rezk *et al.*, 2024)
Host Community Representatives	Niger Delta community associations such as: 1. Ogoni Central Indigenous Authority (OCIA) 2. Kula Community Development Committee (Kula CDC)	Niger Delta community leaders and local power brokers	1. Distrust of government and companies limits collaboration 2. Social unrest and environmental degradation hinder CE projects (Oyefusi, 2007)
Political Office Holders	1. Ministry of Petroleum Resources (MPR) 2. Federal Ministry of Environment 3. National Assembly Committees	Initiate, formulate, and oversee policies and programmes for the advancement of the oil and gas sector	1. Political priorities focused on revenue maximization over sustainability 2. Frequent changes and lack of continuity in sectoral reforms (Oyefusi, 2007; Adebayo *et al.*, 2024)
Universities and Research Organisations	1. Universities 2. Research institutes 3. Innovation hubs 4. Knowledge centres	Knowledge production, research and development, capacity building, and innovation support	1. Facilitate knowledge exchange and innovation 2. Support development of sustainable technologies and practices 3. Act as intermediaries between industry, government, and society 4. Limited influence where industry–academia collaboration is weak (Parrilli and Sacchetti, 2008)

The diversity of organisations that may be involved in transitions to a circular economy offers considerable challenges and complexity for integration and collaboration between these organisations in the Oil and Gas sector to ensure sustainable development outcomes (Semlinger, 2008). The next section proposes a framework to address these challenges.

3. CONCEPTUAL FRAMEWORK

Building on the theoretical perspectives introduced in section 1, this section elaborates on the Industrial Network Approach (INA) and the Actor, Resources Activities (ARA) model, dubbed in this paper INA/ARA for short, and the Multi-Level Perspective (MLP), which captures how actor interactions and resource configurations within industrial networks both shape and are shaped by broader institutional and regime-level conditions, including sustainability transitions.

The INA/ARA framework provides a relational perspective for understanding how organisations interact between each other in dyads (two companies) immersed in networks. Actors, resources and activities are constituting elements of relationships which are structured through processes of interconnection. Actors are organisations or individuals involved in networks; resources include both physical and non-physical assets and activities refer to processes through which resources are transformed and exchanged. These elements are interdependent, meaning that changes in one element can influence the others.

From this perspective, dyads are embedded within networks of long-term relationships characterised by interdependencies between organisations (Håkansson and Snehota, 1995b). Thus, rather than operating independently, firms coordinate activities, exchange resources, and adapt to each other through ongoing interactions within industrial networks.

ARA works at individual organization level, where activities create activity structures and competences through collection of resources by actors (e.g. managers) within organizational structures (Stål *et al.*, 2026). Companies establish relationships with other companies, constituting dyads. These relationships originate and develop through establishing actor *bonds*, resource *ties* and activity *links*, originating novel competences and resources through mutual adaptation, continuity and investment (Ibid).

In turn, companies are integrated in the context of networks composed of interconnected dyads (Håkansson and Snehota, 1995b) within which these relationships are interwoven. This originates activity patterns, resource constellations and webs of actors, with multiple interactions resulting in more complex novel competences and resources (Stål *et al.*, 2026).

From this perspective, innovation and organisational change rarely occur through actions of individual firms alone. Instead, they emerge through interactions among multiple actors within industrial networks, where knowledge, technologies, and capabilities are combined and recombined over time (Ford *et al.*, 2008; Möller and Halinen, 2017). Therefore, the implementation of circular economy practices may depend significantly on how organisations collaborate and interact within industrial networks.

INA/ARA has limitations in explaining broader structural and institutional changes. The framework focuses primarily on network-level interactions and therefore offers limited insight into how wider socio-technical forces, such as regulatory change, environmental pressures, and macro-level dynamics, shape the development and diffusion of circular economy practices (Eklund and Waluszewski, 2017). The study also suggests that INA/ARA overlooks critical aspects of relationship and network development such as culture, values, meaning and social practices. These limitations can be addressed by drawing on the MLP.

The MLP holds that sustainability transitions are influenced by broader structural dynamics and explains how socio-technical transitions occur through interactions between niche innovations, established regimes, and broader landscape pressures (Geels, 2002). From this view, transitions occur across three analytical levels. Niches represent protected spaces where radical innovations emerge and develop through experimentation and learning. Regimes refer to the dominant structures, rules, and practices that stabilise existing systems, including established technologies, regulations, infrastructures, and industry routines. The socio-technical landscape represents broader contextual developments such as environmental pressures, economic trends, cultural values, and political change that can exert pressure on existing regimes (Geels, 2002a; Geels and Schot, 2007).

Transitions occur when niche innovations gain momentum while landscape pressures destabilise existing regimes, creating opportunities for new technologies and practices to diffuse more widely. In the context of the oil and gas sector, emerging circular economy initiatives such as waste valorisation, flare gas recovery, and resource reuse can be understood as niche-level innovations that challenge existing linear production practices within the sector. However, the MLP also has limitations. It does not address the micro-level interactions between actors nor it explains how relationships, resource dependencies, and coordination processes within industrial networks influence the implementation of innovations in practice (Smith *et al.*, 2010; Genus and Coles, 2008).

Therefore, this paper integrates INA/ARA and the MLP to demonstrate how circular economy transitions are realised through the interplay between network-level interactions and broader socio-technical dynamics. While the MLP captures the broader structural conditions influencing sustainability transitions and provides valuable insights into the structural dynamics of sustainability transitions and a robust framework for understanding system-level transitions, INA/ARA focuses explicitly on relationships and interaction processes within industrial networks and can explain how these transitions are enacted through interactions between actors within industrial networks. This can enable a multi-level understanding of circular economy implementation, linking network dynamics with wider socio-technical transformation processes. The next section discusses how the conceptual framework can be applied to research in transitions in the Oil and Gas industry in Nigeria.

4. DISCUSSION

This paper contributes to the IMP literature by demonstrating how integrating INA/ARA and the MLP advances understanding of how circular economy transitions are implemented through industrial networks in Nigeria's oil and gas sector. The transition to a circular economy is more urgent than ever, not only to reduce the impact of waste release in the environment and revalorise waste to extract economic benefits, where feasible. World instability and recent geopolitical tensions, including the invasion of Ukraine by Russia and tensions in the Middle East, exposed inherent vulnerabilities of the world economy in respect to its energy requirements and critical resources (McIlroy, 2026). For the Oil and Gas sector in Nigeria, and elsewhere, the need to reduce the impact of their industry sector on the environment, and address security of supply and market turbulence, stresses the urgency of conducting research on transitions to circular economic models. For this very purpose, the paper has proposed the operationalisation of a conceptual framework which draws on two existing research approaches, the Industrial Network Approach (INA) together with the Actors, Resources and Activities (ARA) frameworks, developed by Håkansson and Snehota (1995a), and the Multi-Level Perspective (MLP) developed by Geels (2002b). The MLP is deemed useful to explore

the transition to a circular economy with a special focus on the socio-technical landscape level, which is timely, considering the "shocks" the global theatre might be subjected to following developments hinted to above.

To address the limitations of MLP explained in section 3, the INA/ARA framework helps investigating how industrial networks constituted by actors in Oil and Gas industry in Nigeria and beyond can be structured and operated to generate and nurture the innovations necessary to transition to circular business models in that industry. Ensuring that these networks generate positive outcomes requires governance of the socio-technical regime, to dissuade the actors involved from limiting their focus to profits and self-interest (Loeber and Kok, 2024). These potentially malevolent endeavours may result in divergence and conflict between partners as they prioritise their corporate objectives (Semlinger, 2008). To ensure the transition to circular economic models has positive outcomes for sustainable development, the networks need to be collaborative (ibid.). This presents a challenge for researchers because, when combining INA/ARA with the MLP, they need to address network actors along with policy, cultural, and technical developments in the socio-technical landscape. This requires interrogating government actors, universities, and not-for-profit organisations, as Table 1 illustrated and argued by Parrilli and Sacchetti (2008).

This paper suggests that drawing on INA/ARA and MLP will assist with exploring the complexities of the transition to the CE. The authors will need to take into account whether the two frameworks are commensurate in order to design a conceptual framework which combines and integrates them, or operationalise the two perspectives in parallel (Stirling, 2011). Whilst a decision needs to be made on this issue, which may require multiple data collection stages, this paper argues that the research is of an explorative nature and requires appropriate methodologies to explore this specific context, adopting a constructivist paradigm as recommended by Saunders *et al.* (2019). Such an approach is particularly suitable for examining complex social phenomena involving multiple actors, institutional arrangements, and evolving practices.

5. CONCLUSION

This paper contributes to IMP literature by demonstrating the importance of understanding how transitions from linear to CE models are shaped by interactions within industrial networks, through the integration of INA/ARA and the MLP. The paper has framed this transition within the context of the oil and gas industry in Nigeria, which presents considerable challenges. The paper proposes to address the question of how governed industrial networks may support a transition to a circular economy in the industry. Having considered the exploratory nature of the research, this paper recommends a qualitative research design, drawing on interviews and focus groups to explore how industrial networks influence the implementation of CE practices within the Nigeria's oil and gas sector, in addition to documentary evidence to research policy. The paper also recommends a constructivist epistemological position that seeks to understand how stakeholders perceive and engage with circular economy initiatives within industrial networks. Given its economic significance and the environmental challenges associated with oil extraction and processing, Nigeria's oil and gas sector represents a critical empirical context for advancing research on circular economy transitions.

In so doing, the paper advances a multi-level understanding of how CE transitions are configured through the interplay between network dynamics and socio-technical structures.

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